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How to Utilize Forecasts Produced by the ARIMA Model to Solve Persistently High Neonatal Mortality Rates in Mali

[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - Ending all avoidable neonatal deaths by the end of 2030 is the focus of SDG-3 target 3.2.The current progress made on the reduction of neonatal deaths in Mali is not impressive due to a number of reasons which include poverty and political unrest. This study uses annual time series data on neonatal mortality rate (NMR) for Mali from 1964 to 2019 to predict future trends of NMR over the period 2020 to 2030. Unit root tests have shown that the series under consideration is an I (1) variable. The optimal model based on AIC is the ARIMA (1,1,5) model. The study results showed that neonatal mortality is expected to gradually decline but will remain high throughout the out of sample period. Therefore, health authorities in Mali are encouraged to draft and implement local policies that can effectively address neonatal mortality with focus being given to medical staff retention, availing adequate medical supplies at all levels of care and regular training of medical staff on basic &emergency obstetric and essential newborn care.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Mali is one of the poorest countries in the world, with 50.1 percent of the population living below the international poverty line of 1.25 US $per day. Over the past decade political and religious unrest has been a major setback. There are high child, infant and neonatal mortality rates of 111, 75 and 38/ 1000 live births, respectively (UNICEF, 2017). According to the Mali Demographic health survey, in 2018 total fertility rate was 6.3, maternal mortality ratio at 325 deaths per 100 000 live births, under 5 mortality of 101 per 1000 live births, infant mortality stood at 54 deaths per 1000 live births and neonatal mortality rate of 33 per 1000 live births. It is worth to mention that global under 5 mortality has dropped significantly, however Mali's estimates continue to be on the high side (You *et al*. 2015). Neonatal mortality remains a public health threat even for Mali. In 2015 the country reported a neonatal mortality rate (NMR) of 38 deaths per 1000 live births (UNICEF, 2015). The main aim of this study is to model and project neonatal mortality rate for Mali using the Box-Jenkins ARIMA procedure. The model is appropriate for modeling linear data (Nyoni, 2018; Box & Jenkins, 1970). The findings of the study are expected to guide planning, decision making and allocation of resources towards Maternal and Child health programs. It is envisioned that appropriate neonatal intervention strategies will be implemented to control neonatal mortality in the country and significantly reduce neonatal mortality rate to at least 12 per 1000 live births by 2030.

II. LITERATURE REVIEW

A description of household factors associated with under-five mortality in Bankass, a remote region in central Mali was done by Boettiger *et al*. (2021). The authors analyzed baseline household survey data from a trial being conducted in Bankass. The survey was administered to households between December 2016 and January 2017. Under-five deaths in the five years prior to baseline were documented along with detailed information on household factors and women's birth histories. Factors associated with under-five mortality were analyzed using Cox regression. The study concluded that U5 mortality is very high in Bankass and is associated with living a greater distance from healthcare and several other household factors that may be amenable to intervention or facilitate program targeting. Ewere & Eke (2020) investigated the impact of maternal / child care characteristics on neonatal mortality in Nigeria using the logistic regression model. The study concluded that stake holders in the public health sector must improve the quality of existing health care facilities and access to quality services in order to substantially reduce neonatal mortality in the country. A cross-sectional study carried out by Edem *et al.* (2020) examined the health practices, care-seeking behavior, and referral of sick out-born neonates to a district and regional hospital in the Upper West Region of Ghana. The study findings suggested that socio-cultural factors strongly influence health seeking behavior and the health outcome of neonates

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in this setting. A similar cross-sectional study in Ghana was done by Annan & Asiedu (2018) who applied the logit model to assess the maternal, neonatal, and health system related factors that influence neonatal deaths in the Ashanti Region, Ghana. The authors concluded that there was a high number of neonatal deaths which were mainly caused by birth asphyxia, infections, congenital anomalies and respiratory distress syndrome. Merabet *et al.* (2018) described neonatal deaths and identified their risk factors at the Al Hoceima Provincial Hospital. The findings showed that neonatal mortality in the Al Hoceima hospital remains high and is mainly related to the course of pregnancy and childbirth as well as the characteristics of the newborn at birth.

III. METHODOLOGY

The Box – Jenkins Approach

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018). The Box – Jenkins technique was proposed by Box & Jenkins (1970) and is widely used in many forecasting contexts.

Data Issues

This study is based on annual NMR in Mali for the period 1964 to 2019. The out-of-sample forecast covers the period 2020 to 2030. All the data employed in this research paper was gathered from the World Bank online database.

Evaluation of ARIMA Models

Criteria Table

Table 1: Criteria Table

Model Selection Criteria Table			
Dependent Variable: D(M)			
Date: 01/23/22 Time: 17:47			
Sample: 1964 2019			
Included observations: 55			
Model	LogL	AIC*	BIC
(1,5)(0,0)	28.662686	-0.751370	-0.459395
(3,5)(0,0)	29.847047	-0.721711	-0.356741
(2,5)(0,0)	28.667505	-0.715182	-0.386709
(3,4)(0,0)	28.534405	-0.710342	-0.381869
(4,4)(0,0)	29.532306	-0.710266	-0.345296
(4,5)(0,0)	30.463548	-0.707765	-0.306299
(2,4)(0,0)	27.175707	-0.697298	-0.405323
(0,5)(0,0)	25.971308	-0.689866	-0.434387
(1,4)(0,0)	25.466548	-0.671511	-0.416032
(2,0)(0,0)	22.039332	-0.655976	-0.509988
(4,1)(0,0)	24.904812	-0.651084	-0.395605
(4,0)(0,0)	23.771297	-0.646229	-0.427247
(2,3)(0,0)	24.631249	-0.641136	-0.385658
(1,2)(0,0)	22.559581	-0.638530	-0.456045
(2,2)(0,0)	23.438015	-0.634110	-0.415128
(5,1)(0,0)	25.389588	-0.632349	-0.340373

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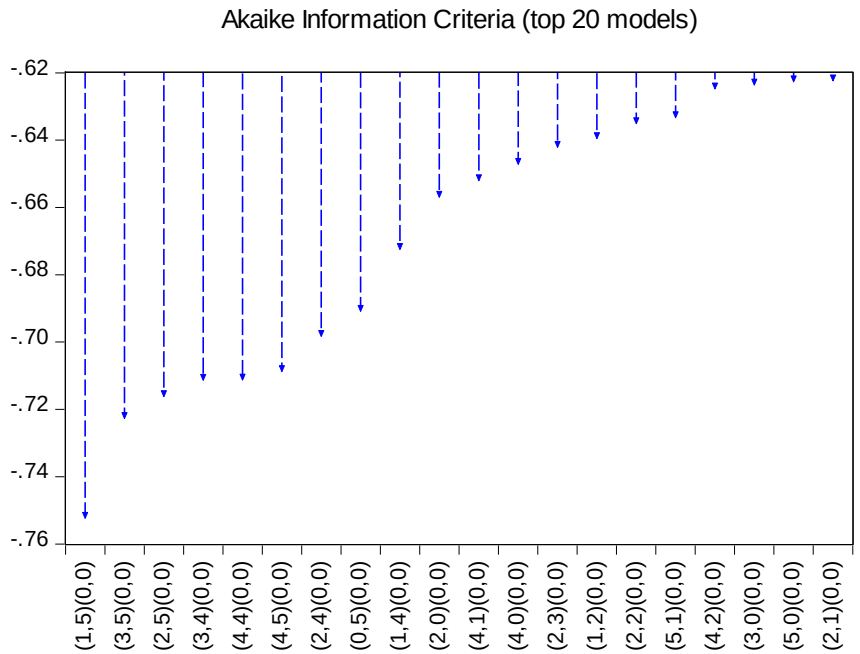
(4,2)(0,0)	25.154498	-0.623800	-0.331824
(3,0)(0,0)	22.122725	-0.622645	-0.440160
(5,0)(0,0)	24.095431	-0.621652	-0.366173
(2,1)(0,0)	22.088835	-0.621412	-0.438927

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

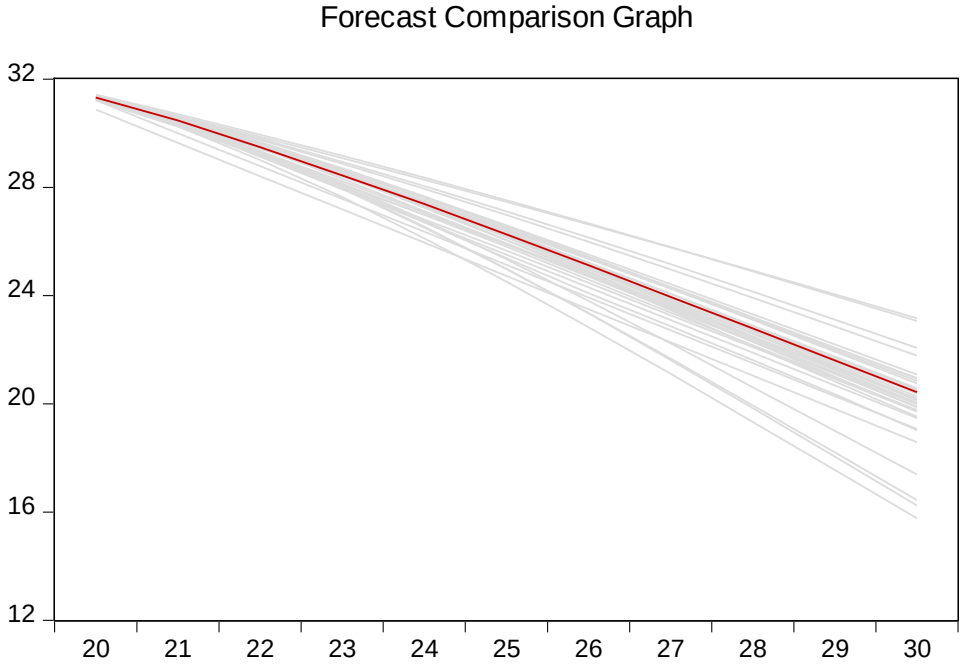


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (1,1,5) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (1,1,5) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	31.31547403927811
2021	30.46554974419808
2022	29.47845174191036
2023	28.44169868230816
2024	27.38412021429262
2025	26.26354901628408
2026	25.11344766123834
2027	23.94950295990899
2028	22.77906868129475
2029	21.60559217484964
2030	20.4306895123132

Table 2 clearly indicates that neonatal mortality is expected to gradually decline but will remain high throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The government of Mali amongst other challenges continues to battle the problem of neonatal mortality. The 2018 DHS reported high maternal, under five and neonatal mortality rates. The country's under five mortality rates have remained very high when compared to global estimates. Several factors have been found to influence neonatal mortality such as proximate, socio-demographic and cultural factors. In this paper we apply the ARIMA model to predict future trends of NMR for Mali and the model projections revealed that neonatal mortality is expected to gradually decline but will remain high throughout the out of sample period. Therefore, health authorities in Mali are encouraged to draft and implement local policies that can effectively address neonatal mortality with focus being given to medical staff retention, availing adequate medical supplies at all levels of care and regular training of medical staff on basic& emergency obstetric and essential newborn care.

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